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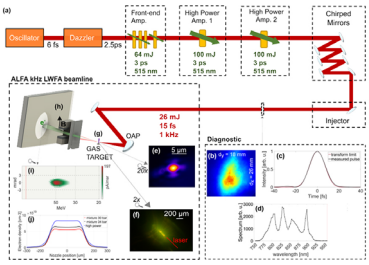
Using a terawatt laser with a kHz pulse rate, electrons can be accelerated to high relativistic speeds over sub-millimeter distance.



Electron beams are valuable tools in medicine, where they are used for imaging, cancer treatments, and device sterilization. These beams are typically powered via radio-frequency acceleration, which is effective but fundamentally limited in its maximum achievable acceleration gradient. For medical applications, these high-energy beams require long accelerator distances and large, expensive equipment.

Lazzarini et al. demonstrated a new high-energy laser-driven electron beam accelerator capable of generating pulses up to 50 MeV at a continuous 1 kHz frequency. Their system can reach these high energies with a very small sub-mm gas target. This result represents a global record for laser-driven beam energy at a kHz frequency, putting it within the desired range for medical applications such as electron radiotherapy.

While electron beams have been driven to even higher energies by higher-power lasers before, they could never achieve both high-energy electrons and fast repetition rates.

“Before this, it was either a high energy beam but only a few shots per second or a kHz beam but at a lower energy, about a few MeV up to 15 MeV,” said author Carlo Maria Lazzarini.

The researchers employed the advanced L1-Allegra OPCPA TW laser system with a kHz pulse rate focused tightly on a gas target, producing electron beams through wakefield acceleration. Their results demonstrate this technique’s potential and offer encouragement for even more ambitious experiments.

“In the future, we have the possibility to go into the hundreds of MeV at 1 kHz, or we could increase the repetition rate from 1 kHz to 5 kHz,” said Lazzarini. “With this electron beam, there is also a possibility to generate kHz X-ray beams with different techniques.”

Source: “Ultrarelativistic electron beams accelerated by terawatt scalable kHz laser,” by C. M. Lazzarini, G. M. Grittani, P. Valenta, I. Zymak, R. Antipenkov, U. Chaulagain, L. V. N. Goncalves, A. Grenfell, M. Lamac, S. Lorenz, M. Nevrkla, A. Spacek, V. Sobr, W. Szuba, P. Bakule, G. Korn, and S. V. Bulanov, *Physics of Plasmas* (2024). The article can be accessed at https://doi.org/10.1063/5.0189051.